

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

LINED WATERWAY OR OUTLET

(Ft.)

CODE 468

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, synthetic turf reinforcement fabrics, or other permanent material.

space.

4. Soils are highly erosive or other soil or climatic conditions preclude using vegetation only.

PURPOSE

This practice may be applied as part of a resource management system to support one or more of the following purposes:

- Provide for safe conveyance of runoff from conservation structures or other water concentrations without causing erosion or flooding
- Stabilize existing and prevent future gully erosion
- Protect and improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff, steep grades, wetness, prolonged base flow, seepage, or piping is such that a lining is needed to control erosion.
2. Use by people or animals precludes vegetation as suitable cover.
3. High-value property or adjacent facilities warrant the extra cost to contain design runoff in a limited

CRITERIA

GENERAL CRITERIA APPLICABLE TO ALL PURPOSES

Capacity

The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft³/s (5.67m³/s). The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour frequency storm.

Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish.....	0.012 – 0.014
Float	0.013 – 0.017
finish.....	0.016 – 0.022
Shotcrete.....	0.020 – 0.025
Flagstone.....	
^{1/2} Riprap - (Angular Rock)	$n = 0.047(D_{50} S)^{0.147}$
Synthetic Turf	Manufacturer's
Reinforcement Fabrics and	recommendations
Grid Pavers	

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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1/ Applies on slopes between 2 and 40% with a rock mantle thickness of $2 \times D_{50}$ where:

D_{50} = median rock diameter (in.),

S = lined section slope (ft./ft.) (.02 = S = .4)

Velocity

Maximum design velocity and rock gradation limits for rock riprap-lined channel sections shall be determined using NEH, Part 650, Engineering Field Handbook, Chapter 16, Appendix 16A, unless a detailed design analysis appropriate to the specific slope, flow depth and hydraulic conditions indicate that a higher velocity is acceptable.

Maximum design velocity for concrete-lined sections should not exceed those using Figure 2.

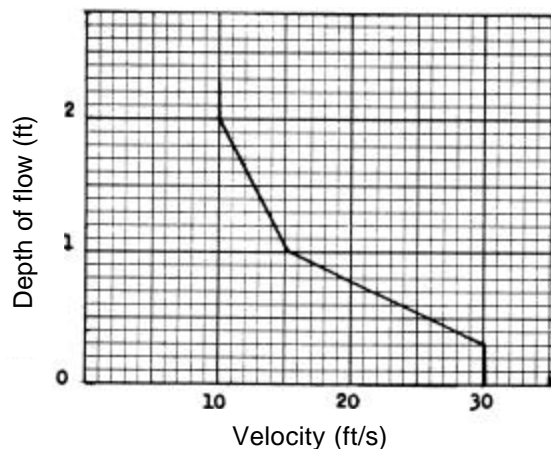


Figure 2. Maximum velocity versus depth of flow for concrete-lined channels

Maximum design velocity for synthetic turf reinforcement fabrics and grid pavers shall not exceed manufacturer's recommendations.

Stable rock sizes and flow depths for rock-lined channels having gradients between 2 percent and 40 percent may be determined using the following detailed design process. This design process is from **Design of Rock Chutes** by Robinson, Rice, and Kadavy.

For channel slopes between 2% and 10%:

$$D_{50} = [q(S)^{1.5}/4.75(10)^{-3}]^{1/1.89}$$

For channel slopes between 10% and 40%:

$$D_{50} = [q(S)^{0.58}/3.93(10)^{-2}]^{1/1.89}$$

$$z = [n(q)/1.486(S)^{0.50}]^{3/5}$$

Where

D_{50} = Particle size for which 50% of the sample is finer, in.

S = Bed slope, ft./ft.

z = Flow depth, ft.

q = Unit discharge, $\text{ft}^3/\text{s}/\text{ft}$

(Total discharge÷Bottom width)

Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical velocity shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical velocity shall discharge into an energy dissipator to reduce discharge velocity to less than critical.

Side slope

The steepest permissible side slopes, horizontal to vertical, shall be:

Nonreinforced concrete:

Hand-placed, formed concrete

Height of lining, 1.5 ft or less Vertical

Hand-placed screeded concrete or mortared in place flagstone

Height of lining, less than 2 ft 1 to 1

Height of lining, more than 2 ft 2 to 1

Slip form concrete:

Height of lining, less than 3 ft 1 to 1

Rock riprap 2 to 1

Synthetic Turf Reinforcement Fabrics 2 to 1

Grid Pavers 1 to 1

Cross section

The cross section shall be triangular, parabolic, or trapezoidal. Cross section made of monolithic concrete may be rectangular.

Freeboard

The minimum freeboard for lined waterways or outlets shall be 0.25 ft (8 cm) above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved or reinforced side slopes. No freeboard is required if vegetation can be grown and maintained.

subgrade through the lining material.
Geotextiles shall be designed according to AASHTO M288, Section 7.3.

Lining thickness

Minimum lining thickness shall be:

Concrete.....4 in. (10 cm) (In most problem areas, minimum thickness shall be 5 in. (13cm) with welded wire fabric reinforcing.)

Rock riprap.....Maximum stone size plus thickness of filter or bedding

Flagstone.....4 in. (10 cm), including mortar bed

Synthetic Turf

Reinforcement Fabrics

and Grid Pavers.....Manufacturer's Recommendations

Lining Durability

Use of non-reinforced concrete or mortared flagstone linings shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

Related structures

Side inlets, drop structures, and energy dissipators shall meet the hydraulic and structural requirements for the site.

Outlets

All lined waterways and outlets shall have a stable outlet with adequate capacity to prevent erosion and flooding damages.

Geotextiles

Geotextiles shall be used where appropriate as a separator between rock, flagstone, or concrete linings and soil to prevent migration of soil particles from the

Filters or bedding

Filters or bedding shall be used where appropriate to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to NRCS standards. Weep holes may be used with drains if needed.

Concrete

Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of 3,000 pounds per square inch (211 kg/cm²).

Contraction joints

Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet (3-4.5m). Provide welded wire fabric or other uniform support to the joint to prevent unequal settlement.

CONSIDERATIONS

Cultural resources need to be considered when planning this practice. Where appropriate, local cultural values need to be incorporated into practice design in a technically sound manner.

Consider adding widths of appropriate vegetation to the sides of the waterway for wildlife habitat.

Important wildlife habitat, such as woody cover or wetlands, should be avoided or protected if possible when siting the lined waterway. If trees and shrubs are incorporated, they should be retained or planted in the periphery of the grassed portion of the lined waterways so they do not interfere with hydraulic functions and roots do not damage the lined portion of the waterway. Mid- or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands.

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway. Crossing design shall not interfere with design flow capacity.

Establish filter strips on each side of the waterway to improve water quality.

When designing riprap linings and specifying rock gradations, consider that rock delivered to the site is often segregated by size or does not conform exactly to the specified gradation. Adequate safety factor should be incorporated.

PLANS AND SPECIFICATIONS

Plans and specifications for lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s).

DESIGN DATA

As a minimum, record and maintain the following planning and design data. Include this information on either the drawings, the design sheets, or the engineering field book, as appropriate.

1. Completed Form VA-EE-1.
2. Location map. Include tract number, field number(s), and acreage in field(s). Include a plan view of the lined waterway or outlet in relation to an identifiable point. Include buildings or other structures that affect the design.
3. Drainage area, landuse, and design volume.
4. Computed design velocity.
5. Design grade, bottom width, average depth, side slopes, and hydraulic gradient for each design section.
6. Engineering Layout Surveys.
7. Soil borings, where applicable.

8. Yardage calculations when needed for performance certification.
9. Outlet conditions.
10. Cross-references to appropriate engineering field books will be made on drawings and plans.
11. Recommendations for vegetation along practice.

CHECK DATA

As a minimum, record and maintain the following check data:

1. For each design section, record cross-section notes to show grade, bottom width, top width, depth, and side slopes.
2. Length of lined waterway or outlet installed.
3. Adequacy of outlet.
4. Certification that practice meets standards and specifications. Note any exceptions.
5. A statement that the following have been satisfactorily completed:
 - a) Spoil spreading
 - b) Seeding or successful establishment of vegetation.

OPERATION AND MAINTENANCE

Operation and maintenance requirements shall be provided to and reviewed with the landowner. The requirements shall include the following items and others as appropriate.

A maintenance program shall be established to maintain waterway capacity and outlet stability. Lining damaged by machinery or erosion must be repaired promptly.

Inspect lined waterways regularly, especially following heavy rains. Damaged areas shall be repaired immediately. Remove sediment deposits to maintain capacity of lined waterways.

Landowners should be advised to avoid areas where forbs have been established when applying herbicides. Avoid using waterways as turn-rows during tillage and cultivation operations. Prescribed burning and mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover. Control noxious weeds. Do not use as a field road. Avoid crossing with heavy equipment.

REFERENCES

1. National Engineering Handbook, Part 650, Engineering Field Handbook: Chapter 16, Streambank and Shoreline Protection.
2. Robinson, K.M., C.E. Rice, and K.C. Kadavy. 1998. Design of Rock Chutes. Transactions of ASAE, Vol. 41(3): 621-626.
3. 700 Series Construction Specifications.
4. Appropriate Technical Releases and Design Notes, USDA, NRCS.
5. AASHTO M288, Section 7.3.
6. General Manual, 190, Part 410, Compliance with NEPA.

NATURAL RESOURCES CONSERVATION SERVICE
VIRGINIA CONSERVATION PRACTICE STANDARD
LINED WATERWAY OR OUTLET

Approved Practice Narrative
(Ft.)

CODE 468

468 D1 Lined Waterway or Outlet: A lined waterway or outlet capable of carrying the intended peak runoff shall be installed in keeping with this standard and in accordance with all local, state, and federal laws, guidelines, and permits.

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